Final Report – Volume 1 | *Covering the Period 1 September 1962 through 29 February 1964*

RESEARCH ENGINEERING AND SUPPORT FOR TROPICAL COMMUNICATIONS

Prepared for:

U.S. ARMY ELECTRONICS LABORATORIES
FORT MONMOUTH, NEW JERSEY

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PREFACE

This report summarizes work completed and work under way during the period 1 September 1962 through 29 February 1964~~, on Contract DA-36-039-AMC-00040 (E)~~. The effort described in this report involves an investigation of radio communication problems of concern to Project AGILE.

Owing to the joint working arrangements existing between Thailand Ministry of Defense personnel, the U.S. Advanced Research Projects Agency Field Unit, U.S. Army Electronics Laboratory personnel, and U.S. Army Signal Radio Propagation Agency personnel, overlapping and joint working parties are assigned to technical problems. An attempt has been made in the report to properly give credit to the many organizations involved.

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CONTENTS

ILLUSTRATIONS

I HISTORICAL BACKGROUND

During World War II, United States military forces operated extensively in tropical areas, thereby gaining considerable practical experience in communication problems in tropical forests and jungle areas. Unfortunately, the pressure of military objectives limited scientific exploration into many of the specific problems that arose. Sizable gaps in our knowledge of communication in equatorial regions remained. The present-day interest of the United States in assisting and promoting the development of nations in these regions has revived interest in communication problems and capabilities there.

Under Project AGILE, the Advanced Research Projects Agency (ARPA) of the United States Department of Defense has been conducting various programs that provide research and engineering support to enhance the capabilities of friendly local forces in remote areas of potential or actual conflict and to benefit the United States through strengthening those countries, deriving guidance for the conduct of remote area operations, and determining requirements for related research and development. Special emphasis has been given to the problems of communication in southeast Asia, where this portion of AGILE has been identified as SEA CORE, an acronym for South East Asia Communication Research Program.

The friendly and cooperative working arrangement existing between Thailand and the United States has resulted in joint study of tropical communication problems by staff members of the Thailand Ministry of Defense and agencies of the United States Government. Several years ago, a joint Thailand-United States agency called the Combat and Development Test Center (CDTC) was established to conduct realistic tests of military hardware and to foster research on many subjects in a tropical environment. The CDTC was staffed by personnel from the Thailand Ministry of Defense and from ARPA. Support was obtained from many additional Thailand and United States agencies. Under ARPA guidance, the United States Army Electronics Laboratory (USAEL) undertook the support of communication

research in Thailand. Stanford Research Institute, under contract to USAEL, has implemented the various investigations concerning communications. In early 1964, the name of the joint Thailand-United States agency was changed to the Military Research and Development Center (MRDC)* to better describe the function of the organization.

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* Except in direct quotation, current nomenclature is used in the following sections of this report.

II FACILITIES

A. Introduction

Early in the SEA CORE program it was contemplated that an electronics laboratory would be established in Thailand as soon as practicable, with a staff conducting research jointly with Thai personnel. Office space, necessary storage, and housekeeping services were to be provided, and a van-mounted C-2 vertical-incidence ionosonde was to be collocated with the laboratory by the U.S. Army Signal Radio Propagation Agency (USASRPA). It was anticipated that the laboratory proper could best be configured in vans fabricated and equipped in the United States and then shipped for immediate emplacement and operation.

Considerations of availability, reliability, stability, and price indicated that it would be advisable to furnish an independent power-generating capability, at least for the laboratory and sounder. Transportable van and power-generating capabilities also seemed desirable to permit field experimentation remote from the laboratory. It was anticipated that suitable office and storage space with contiguous land area for the laboratory, antennas, C-2 ionosonde, and power generators could be leased in or near Bangkok.

B. Site Preparation

In December 1962, a field site survey was conducted for the purpose of locating a suitable site near Bangkok for an electronics laboratory and support activities. Mr. W. R. Vincent of SRI and Mr. Howard Kitts of USAEL participated in the survey. Major John Kranz, the onsite representative of USAEL, assisted in liaison with the Thailand Ministry of Defence, the ARPA Thailand Contingent, and required local business organizations. The Jansky & Bailey Corporation had undertaken a survey of Thailand for remote propagation test sites, for a companion program under the direction of ARPA and USAEL. Their experience and knowledge of Thailand were helpful and minimized the work required for the SRI survey. A suitable location was selected near the northern edge of

Bangkok, where a three-story Chinese-style store building existed and adequate rice-paddy land was available.

An advance party of SRI personnel arrived in Thailand in February 1963 to complete lease arrangements and start site preparations. Since a rice paddy is flooded in the course of a year, it was necessary to place rock fill in part of the area to create an elevated surface to receive the van complex and furnish working space. Concrete pads and foundations were required for the laboratory and sounder vans, the sounder antenna, and the power building. Rock fill and topping were also required to improve and create road and parking areas. The power building and shelters for Thai guards and drivers were constructed in the form of sheds. The power building includes space for a small shop and storage of mechanical equipment. Support equipment and diesel generators to furnish 60-cps power to the van complex were received during February, and the generators were installed after completion of the power building. Wood poles were set in the rice paddy for antennas, and a catwalk was constructed to give access when the paddy is flooded. The van area with laboratory, power building, mobile shelters, and a wire fence can be seen in Fig. 1.

The building for offices, which can be seen in the distance in Fig. 1 and in a closer view in Fig. 2, had originally been constructed in the form of five adjoining three-story modules, with solid walls between and separate staircases in each module. It was necessary to open doorways between the modules--to give free access throughout each floor--and to floor over the stairways in each of the three central modules. Other work was also required, including finishing, wiring, lighting, air conditioning, and plumbing.* The upper floors are now occupied by

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* In Thailand it is normal business practice for the lessee to make necessary changes in buildings and property to meet his needs. Hence the construction and installation work was done through contracts with the United States Navy Officer in charge of Construction, Southeast Asia (locally known as OICC) and with local contractors, as well as by SRI personnel.

FIG. 1 PHOTOGRAPH OF MAIN BUILDING – SIDE VIEW

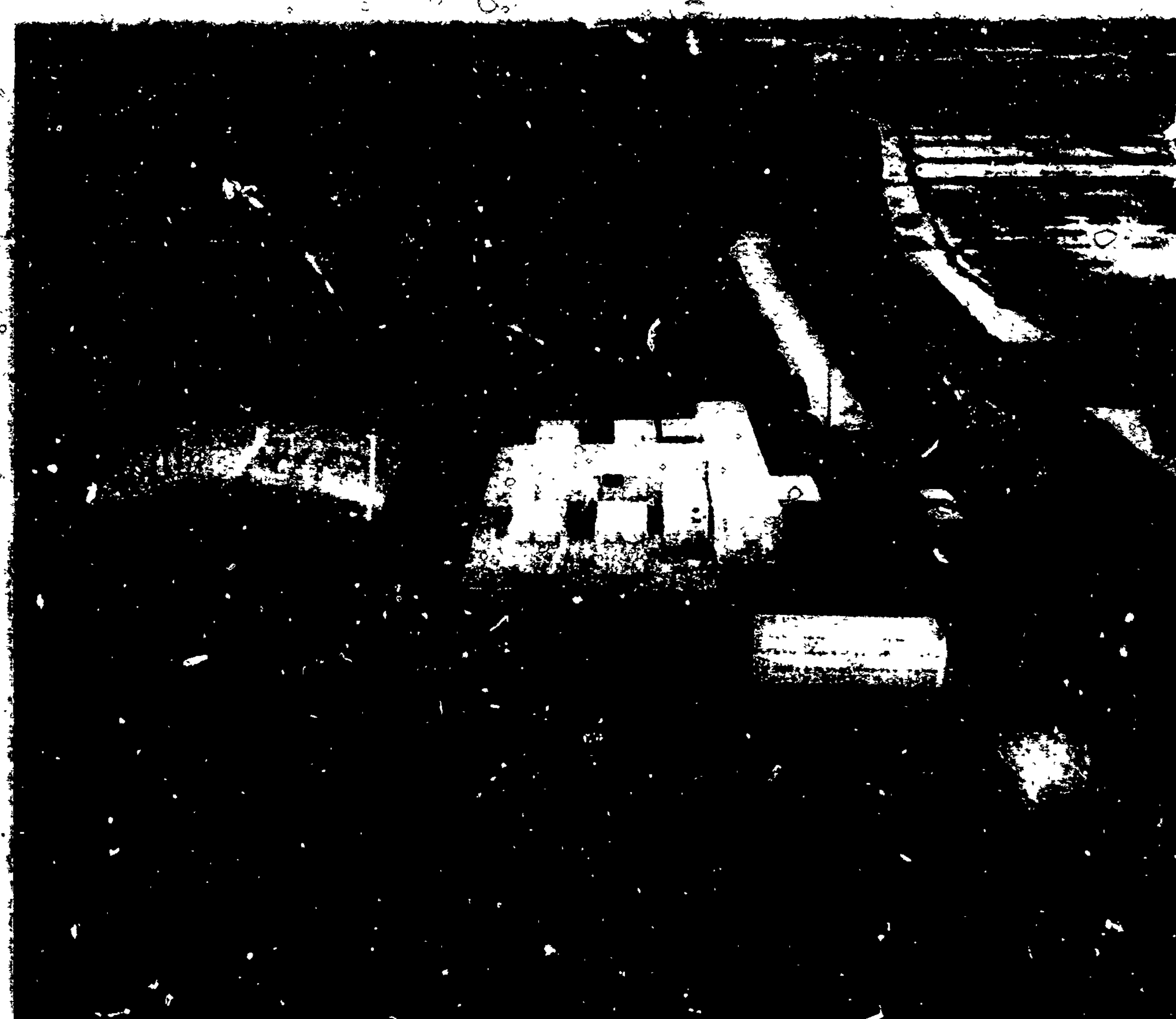

FIG. 2 PHOTOGRAPH OF T-VAN COMPLEX AND POWER BUILDING

offices; one ground-floor module is used for reception; and the remainder of the ground floor provides air-conditioned storage of electronic parts and equipment. Electric power, 50 cps, is furnished from the Bangkok distribution system.

In addition to site preparation in Bangkok, arrangements were made to establish a remote communication testing area about 275 miles south-south-west of Bangkok, near Bang Saphan. Some shelter was already available there (a hunting lodge owned by a Bangkok businessman); this was improved to serve as a headquarters. Several temporary test huts were constructed of locally available materials, over a 23-mile span within a heavily forested area. A typical hut is shown in Fig. 3.

C. MRDC Electronics Laboratory

Simultaneously with the site survey, plans were made at SRI-Menlo Park for the laboratory configuration, laboratory test equipment, and auxiliary equipment. The laboratory proper was designed to take the form of three air-conditioned vans connected in the form of a tee, as shown in Fig. 4. Four field shelters transportable by 2-1/2-ton truck were also provided. The air-conditioned field shelters were equipped with work benches, relay racks, and storage cabinets. An estimated one-year supply of electronic parts and supplies was specified. Owing to the extensive construction and procurement of equipment required to produce the laboratory facility, the USAEL contracted with the Electronics Defense Laboratory (EDL) of Sylvania Electric Products to accomplish this task. Three separate shipments were made from EDL to Thailand, including:

(1) T-van laboratory complex
(2) Power-generating equipment
(3) Test equipment and supplies
(4) Portable shelters for field operation.

Three views of the laboratory interior are shown in Fig. 5. The transportable field shelters can be seen in Fig. 6. The laboratory units, mobile test shelters, test equipment, power generators, and other

FIG. 3 PHOTOGRAPH OF A TEST HUT

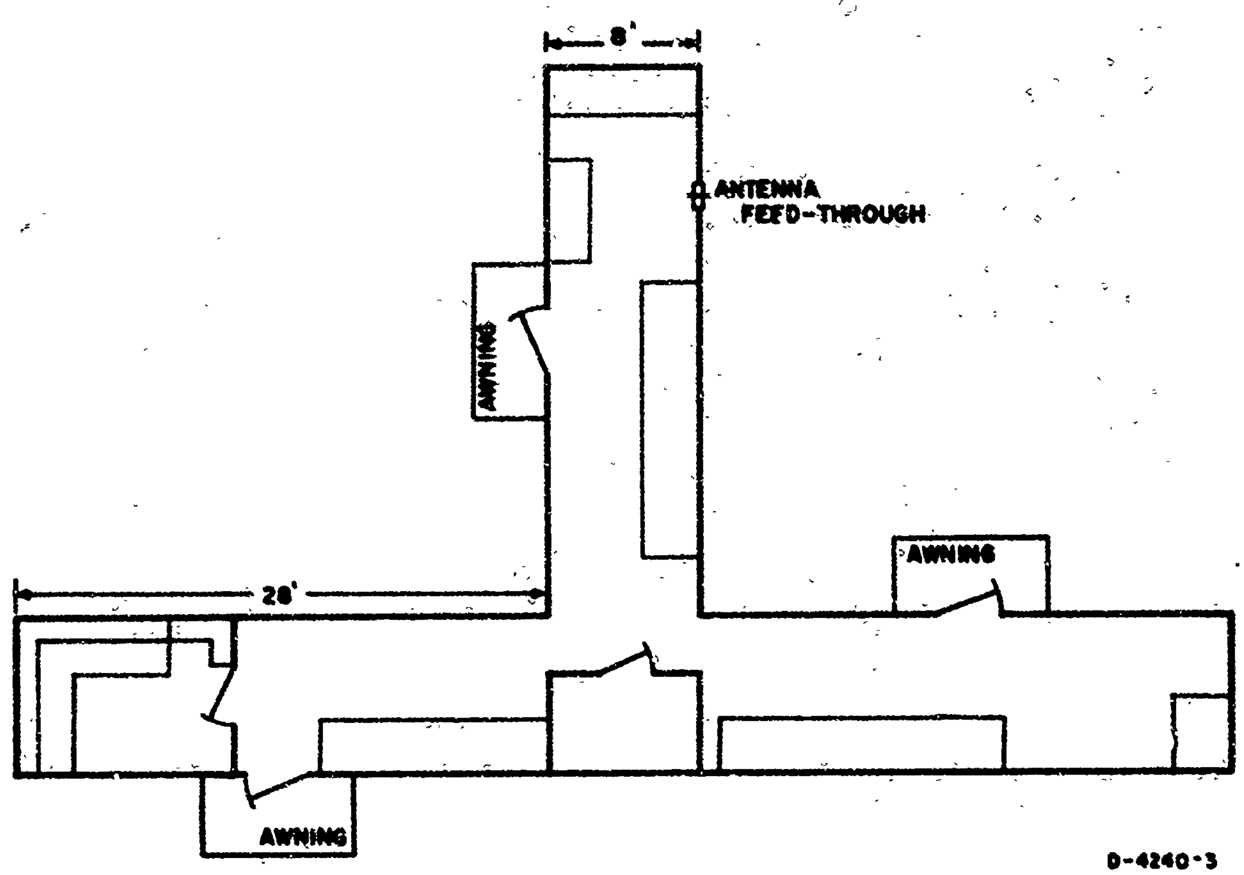

FIG. 4 GENERAL LAYOUT OF MRDC LABORATORY T-VAN COMPLEX

FIG. 5 INTERIOR OF MRDC LABORATORY COMPLEX

FIG. 6 MRDC LABORATORY COMPLEX AND C-2 IONOSPHERE SOUNDER BUILDING

materiel were shipped overseas by air and water during the period February through May 1963 and were installed as they arrived.

During the initial period of the contract, arrangements had been made between ARPA, USAEL, and USASRPA to send a C-2 vertical-incidence sounder to Bangkok. The USASRPA put into excellent condition a van-housed C-2 sounder, shipped the sounder to Thailand, and provided two enlisted men to operate the sounder and to scale data. Prior to the arrival of the sounder van, a small area was filled; a concrete pad was provided for the van; a base and suitable guy anchors were constructed for the sounder antenna; and the antenna tower was erected. Close coordination among those concerned resulted in the C-2 becoming operational very soon after its arrival.

After portions of the main building had been made habitable in the early spring of 1963, some laboratory activities were started. The building, laboratory facilities, and outside work were completed during the summer of 1963; a full schedule of laboratory activity was then initiated. The Electronics Laboratory was dedicated in formal opening ceremonies on 4 October 1963. The remarks at the opening ceremonies by Major General Singchai Menasuta, now Commanding General, MRDC, and by Mr. Thomas Brundage, Director, ARPA/RDFU-T, and the response by Air Chief Marshal Dawee Chullasapya, Chief of Staff, Supreme Command, are reproduced in Appendix A.

The major laboratory equipment provided is listed in Appendix B, including Government-furnished equipment and other equipment added subsequently.

III WORK ACCOMPLISHED DURING THE REPORTING PERIOD--TASK I

A. Introduction

The operations analysis effort during the period covered by this report included some investigation of relevant factors, including Thai speech implications, but was largely devoted to planning of work and preparation of material to be submitted for the approval of higher Thai authorities. This effort was essentially complete when instructions were received to revise the task and subtask statements that had been prepared. The revisions required dwelt more on emphasis and mode of presentation than on substance, and, accordingly, the material previously prepared is presented in this report. It remains largely indicative of the approach to be followed.

At the beginning of the project in September, 1962, it was planned that the initial operations analysis effort would be on the order of one to one-and-one-half men. In November, 1962, the project principals decided that the operations analysis effort should be minimal and largely held in abeyance until completion of the Electronics Laboratory. Commencing in February, 1963, some work was begun to gather background data (approximately three man-months of effort were expended), while commencing in March approximately three man-months were devoted to the question of the implications of Thai speech in regard to communications intelligibility. In May, two staff members were sent to Thailand for a SEATO maneuver. Approximately three man-months were expended. Work again became minimal until late September, 1964, when a project team of five operations analysts was designated. The team members made several field trips and undertook bibliographic research for background information, preparatory to transfer to Bangkok. They arrived in Thailand in November and December of 1963. The months of December, 1963 through February, 1964 were devoted to preparation of a program plan to be submitted for higher-level approval.

B. Objectives

Communications-oriented operations research in accordance with guidance and the Technical Guidelines of July 1962 (as modified by agreement at the time of execution of the contract) is required by the following statement of Task I objectives:

> "This task has for its major objective the survey analysis and evaluation of the capacity reliability and limitations of existing indigenous military communications in the geographic area of interest to the CORC,* to include such related capabilities for communications as are considered appropriate by the Director of CORC....Another objective of this task is to carry out special assignments related to those above. Special attention shall be given to providing short-term feedout of solutions to the above problems, i.e., 'quick-fixes.'"

While the program objectives of Task I have been variously stated in the references cited, they may be generalized and restated as follows:

(1) Determine the requirements for communications capabilities to permit effective counterinsurgency operations by Thai forces.

(2) Compare the communications capabilities that are available or planned with those required, to determine what additional capabilities are required.

(3) Provide the design and analysis for field experimentation, integrating the data from Task II, that will demonstrate in the operational environment the effectiveness of defined capabilities and establish operational requirements for RDT&E programs.

For completeness, the communications assessment and determination of requirements must include those communications required in support of the command and control functions from the Supreme Commander, down through the various command echelons of the military and paramilitary forces, to the remotest outposts and border patrols. Moreover, the support of military command control at all echelons must be envisaged during various levels of conflict, to include enemy infiltration, subversion, passive resistance, guerrilla action, and insurgency on increasing scales;

* CORC is now MRDC.

attacks by irregular external forces; and invasion and/or aggression by organized uniformed enemy forces (i.e., conventional warfare).

C. Over-All Method of Approach

1. General

In this research program, operations analysis is to be conducted in concert with the associated technical investigations of Task II. This will assure the proof of concepts, techniques, and materiel in field experiments, from which communication requirements can be derived. In the following pages, the Task I effort is described in terms of subtask program elements. The work to be performed can be categorized as follows.

(1) Operational Environment

This will consist of:

(a) Studies to determine the operational factors affecting communications within the various environments in Thailand. Later extension of these studies may be made to cover Southeast Asia.

(b) Study of the interrelationship of the four main factors of the environment--i.e., political, military, economic, and sociocultural,* with initial efforts directed to village and district level environments.

(2) Capability Analysis

This category will include:

(a) Analyses of communications capabilities and techniques on a system basis, to assess such factors as their feasibility, costs/time characteristics, performance within operational constraints, and over-all effectiveness

(b) Analysis of component and functional relationships of the systems in the context of their operational use

(c) Examination and assessment of performance specifications

(d) Isolation of the time delays inherent in communications operations in parametric values related to mission accomplishments, operational tactics, and counterinsurgency techniques.

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* Maximum use will be made of data and results from other associated and related operations analysis efforts at MRDC-ARPA/RDFU-T such as RAC, etc.

(3) Comparative Research

Included here will be:

(a) Selection of aspects of the operational environment that prove significant for the evaluation, and investigation related to pertinent environmental conditions in Thailand (extended to Southeast Asia at a later date), where insurgent operations have occurred or may occur

(b) Determination of the operational environmental differences, if any, that might be expected to alter the conclusions reached in the initial evaluations

(c) An attempt to construct a generalized model applicable to the different environmental situations.

(4) Experimental Design and Analysis

The final category will consist of:

(a) Study and definition of the objectives of field experiments in operational and technical terms

(b) Design of tests taking into account those factors uncovered in other areas of the research effort

(c) Outline of the analytical basis for tests, and the types and quantity of data required

(d) Delineation of criteria and establishment of the form of data analysis expected to produce the level of confidence required

(e) Design of formats for observation forms, questionnaires, and logs that will allow systematic treatment of the data entered thereon

(f) Construction of simple models of factors affecting experimental design, where appropriate.

2. Subtask Scheduling

It is apparent from a brief review of the subtasks that they are interrelated and constitute interdependent segments of the overall Task I study. Much of the research effort and needed data are applicable to two or more subtasks, which can, in certain phases, be conducted simultaneously. In other instances the findings or results of one subtask are required in order to continue the work of the second. For example, the results of Subtask 2 (Survey of Existing Communications) must be fairly well completed before an evaluation can be made in Subtask 3

(Estimate of the Communications Situation) of the adequacy of the existing systems to support the current strategies and contingency plans.

3. Types of Data Required

The types of data used in these studies includes or is derived from the following:

(1) Information, together with illustrative maps, indicating current and potential threats, analysis of such threats, and the probability and magnitude of various levels of conflict

(2) Information, along with maps and diagrams, indicating the size, number, types of units, missions, and territorial organization of the respective military and police forces

(3) Descriptions and diagrams illustrating the command control structure of the Thai military and police forces

(4) Diagrams and data indicating the military police and nonmilitary fixed and semifixed communications networks and their terminals in the various military and police headquarters, and/or other communications centers

(5) Manuals, directives, and verbal statements concerning normal and emergency communications procedures and practices

(6) Discussions with communications officials concerning responsiveness, capacity, reliability, and limitations (if any) in equipments, systems, and procedures; and personnel needs

(7) Observations and data gathered by MRDC and other personnel during Thai military, police, and SEATO field tests, exercises, and maneuvers

(8) Review of lists of equipments available to or planned for the Thai Forces.

4. Collection of Background Information

Trips were made to various facilities to obtain information on the subjects of counterinsurgency operations, program organization, and the technical applications of various communications equipments. The visits included:

(1) Army Electronic Proving Grounds, Ft. Huachuca, Arizona

The procedures and format for initiating and conducting field evaluation tests of communication equipment and systems were reviewed. The application of these procedures by the staff at

USAEPG was demonstrated in a briefing on the Army tactical radio interference studies and experiments in progress at that time. Special instrumentation was employed to determine the relative performance levels of voice communication circuits. This special equipment was not considered to be suitable for use in the experiments proposed for Southeast Asia because of the cost as well as the expected maintenance difficulties.

(2) Special Warfare Center, Ft. Bragg, North Carolina

The communication procedures used by various types of special warfare teams were discussed with the instructors and officers of the Center as well as representatives of teams returned from various points. The experiences of these teams were obtained from a large spectrum of situations, ranging from World War II through Korea and Vietnam. Field expediency measures in equipment and operating procedures showed some variation (attributable to time, place, and group mission).

(3) Airborne Electronic and Special Warfare Board, Ft. Bragg, North Carolina

The persons interviewed expressed a desire to have innovations that would enhance the performance of existing operational equipments. Considerable interest was being directed to the development of a low-cost, lightweight, portable, high efficiency antenna for use with small mobile patrols. Several approaches were under consideration that could be applicable in the Southeast Asia operations. Of particular note was the "fishing reel" antenna that could be rapidly set up or dismantled. Also, experiments were being conducted with doublet antennas placed at different heights above the ground.

(4) Southeast Asia

A survey trip was made to Thailand to observe communication operations and procedures in the SEATO maneuvers of 1963. Operating difficulties were discussed with field troops (primarily USA) with respect to the maneuver as well as routine operations. The communication requirements for counterinsurgency operations (at various levels) were reviewed with ARPA personnel in Bangkok and appropriate studies discussed.

A visit was made to the Far East Land Forces, British Commonwealth, Singapore, to obtain information on the procedures used by British Forces during past counter-insurgency operations.

5. Approvals

Although a general overall approval has been received by the Director, ARPA/RDFU-T, for undertaking the task of the SRI contract, it is necessary to obtain the approval of the Commanding General (Major General Singchai Menasuta), Military Research and Development Center, and the Supreme Command, Thailand, for each individual subtask. This approval is required in order to visit various military headquarters, offices, facilities and units, observe military exercises, conduct experiments involving Thai military personnel, and obtain access to essential documents and data. Subtask 1, Small Unit and Patrol Communications, was approved by the Supreme Command on 22 August 1963.

D. Concept, Organization and Status to Date, by Subtask

The following discussion of Subtasks 1 through 6 outlines the areas of research investigation and analysis. As these studies progress, it may be necessary to modify or add to the content of these areas.

1. Subtask 1--Small Unit Patrol Communications*

The territorial borders of Thailand are, for the most part, adjacent to existing or potential reservoirs of communist insurgents, remote from the center of Thai population and industry, and nearly devoid of modern communication facilities. The detection or prevention of insurgent activity along these borders is the responsibility of small units of Border Patrol Police, with Army units in reserve support. Since the effectiveness of action against insurgents generally increases greatly with the speed with which it can be applied, it is obvious that a means of providing timely communications is essential to the efficient and effective performance of these small unit patrols. It is the purpose of this study to investigate how modern communication technology can be applied to improve the performance of the border patrols in safeguarding the Thai borders against insurgent activity.

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* Subtask 1 has already been approved. The work initiated by Dr. A. Barber, ARPA/RDFU, is being continued.

a. Phases

The study will include the following phases:

(1) Development of a detailed definition of present patrol activity, the definition to cover environment, threats, goals, techniques, and resources

(2) Study of modern communications technology and the postulation of potentially advantageous innovations

(3) Calculations of the costs and prospective returns from the postulated innovations and the identification of those which are potentially practical

(4) Conduct of pilot field tests to assess the cost and worth of the proposed innovations

(5) Formulation of recommendations supported by the tests and appropriate to the resources available.

b. Status

The research program for this subtask has been outlined and studies are being made of current border patrol activity. The observations made during field trips to Border Patrol Police Units are being evaluated.

2. Subtask 2--Survey of Existing Communication Systems

a. Objective

The objective of Subtask 2 is to compile a catalog consisting of descriptions of the physical facilities and operating characteristics and capabilities of military, paramilitary, and other government or private fixed and semifixed communications systems.

b. Approach

To obtain the necessary data to evaluate properly the capabilities of each system, it will be necessary to:

(1) Determine the items of data to be gathered

(2) Design the catalog format and data collation system

(3) Identify and locate the various fixed systems

(4) Obtain permission and visit the departments, agencies, or firms where necessary data may be obtained

(5) Visit various field installations, as required, to obtain additional data

(6) Obtain, record, collate, and catalog data.

c. Sources of Data

Data sources will include consultation with Officers in Charge of Communications, and reference to the records of communications for the various Ministries, Departments, and private business firms.

d. Types of Data Desired

The desired data may include or be derived from:

(1) Route map and circuit diagrams

(2) System design specifications--e.g., cable, open wire, microwave, carrier, SSB, FM or AM, number of channels by mode (voice, teletype), multiplex schemes (FDM, TDM, SSB)

(3) Modes of transmission--e.g., Morse, CW telephone, teleprinter

(4) Type and make of equipment

(5) Points of interconnection with other systems and alternate routes

(6) Maintenance practices

(7) Operating and maintenance personnel requirement.

e. Personnel Required and Estimated Length of Time of Subtask

One MRDC-Thai Officer (preferably with a good technical communications background) and two Operations Analysts (SRI) will be needed for a period of approximately 6 months. It is expected that for much of the time these individuals will make visits to pertinent Thai officials and communications installations.

f. Results Expected From This Study

It is expected that the results of this study will:

(1) Develop a central catalog of existing communications systems of Thailand

(2) Develop a procedure for obtaining, recording, and collating data on existing and future communications systems to include modifications and extensions thereto

(3) Provide a ready source of information on the resources in communications systems available in Thailand in the event of national emergency.

g. Status

Subtask 2 has been outlined and the initial field trips made to various private and governmental organizations concerned with communications are being analyzed.

3. Subtask 3--Estimate of the Communication Situation

a. Objectives

The first objective is to review the military strategies and contemplated operations of the Thai Armed Forces against possible threats and military emergencies at various levels of conflict and assess the adequacy of the existing and currently planned communications system to support them.

The second objective of Subtask 3 is to determine additional requirements for communications systems and operations to adequately support such military strategies and contemplated operations, with special emphasis on strengthening Thai counterinsurgency capabilities.

b. Approach

The research effort will include the following steps. First, a review will be made of the strategic Estimate of the Situation. This includes:

(1) The threat analysis--current and potential threats to the security of Thailand from internal and/or external sources

(2) The composition, organization, assigned missions, and rules of the respective Thai military and police forces

(3) The territorial organization of Thailand for national defense; the current deployments and dispositions of various Thai military and police units

(4) The command-control organization, system, and normal channels for exercising the command function from the Supreme Commander down to small tactical elements

(5) War or con..ngency planning--i.e., the plans proposed for the deployme..s and operations of Thai military and police forces at various levels of threat or conflict.

Second, a review will be made of the existing and nonmilitary communications systems, utilizing the information and data obtained in Subtasks 1, 2, 4, and 6. Particular attention will be paid to those communications for command and control from the highest to lowest military echelons.

Third, an evaluation will be made of the adequacy of the existing and currently planned communications systems to support or reinforce the strategies and planned operations of Thai military forces in the various postulated threat situations.

Fourth, conclusions and recommendations will be derived. These will indicate both "quick fix" and long-range solutions, and the relative urgency or priority for action.

c. Types of Data Required

The types of data to be acquired in this study will include or be derived from the following:

(1) Statements, together with illustrative maps, that indicate current and potential threats, analyze such threats, and give the probability and magnitude of various levels of conflict

(2) Statements, along with maps and diagrams, indicating the size, number, types of units, missions and territorial organization of the respective military and police forces

(3) Diagrams illustrating the command-control structure of the Thai military and police forces

(4) Diagrams and data indicating the fixed and semifixed communications networks of the military and nonmilitary police, and their terminals in the various military and police headquarters, and/or other communications centers

(5) Manuals and verbal statements concerning normal and emergency communications procedures and practices

(6) Discussions with communications officials concerning speed of communications, responsiveness, capacities, reliabilities and deficiencies (if any) in equipments and systems, as well as in procedures and personnel needs

(7) Observations and gathering of data by MRDC and SRI personnel during Thai military, police, and SEATO exercises and maneuvers.

(8) Lists of equipment available to or planned for the Thai Forces.

d. Sources of Data

To obtain the data and information essential for this subtask, it will be necessary to have access to and coordinate with officials in various Thai Ministries and agencies and US-associated agencies that may be concerned with (1) intelligence and threat analysis, (2) war, strategic, and contingency planning, (3) military and police command-control organization and operations, (4) system planning and operations for both military and nonmilitary communications systems, and (5) training of Thai Communications Specialists. Accordingly, permission will be necessary for access to and discussions with appropriate personnel in:

(1) The Supreme Command

(2) The Army, Navy, and Air Forces

(3) Police (including urban, provincial, river, and border)

(4) TOT and Ministry of Communications

(5) ARPA sponsored projects of various agencies--e.g., RAC and RAND

(6) OICC officials concerned with communication project

(7) JUSMAG staff elements concerned with intelligence, plans and operations; and with communications, including logistics and training support for communications

(8) Other Thai and US offices and officials it seems desirable to visit during the course of this study.*

* It will be necessary to visit various headquarters, operations centers, and communications installations in Thailand for observation, and to participate in field trips for a first-hand appreciation of the facilities, operations, and procedures employed. As indicated above, the security and sensitivity aspects of these data are recognized, and proper conduct will be scrupulously observed in consulting with the above offices and officials.

e. Estimate of Personnel Required

Personnel required include one full-time Thai military officer, at least of Commander (Navy) or Lt. Col. (Army or Air Force) rank, with access to the Supreme Command (TS clearance); and one full-time US operations analyst (SRI) familiar with military strategy, military operations, military planning at national and smaller unit levels, and with tactical communications (TS clearance).

In addition, the other Thai officers and SRI personnel engaged in Task I will contribute to this effort from time to time as available and appropriate.

f. Estimated Length of Time of Subtask

It is estimated that effort on this subtask wi... continue for the entire length of Task I--i.e., 16 months.

g. Results Expected From This Study

It is expected that the results of this study will: (1) highlight the current military communications problem areas and indicate steps for their solution or improvement, (2) provide procedures for future assessments and evaluations of Thailand's Communication Situation, and the determination of requirements, and (3) train Thai officer participants in the method of approach and techniques for preparing an estimate of the communications situation, for future continuing effort.

h. Status

The research program for this subtask has been outlined. However, research activities are inactive due to the lack of approval by Thai authorities.

4. Subtask 4--Police and Military Interface

a. Objective

The objective of Subtask 4 is to establish requirements for effective interconnection of the police, military, and other communication networks so that operational coordination can be achieved and alternate routing effected in the event of system damage.

b. Approach

Achieving the objective will require a three-part approach to the problem:

(1) A study of the present and potential missions, roles and practices of the police and military organization will be conducted to establish the need for an effective interconnection of communications networks.

(2) A study of the present procedures and interconnection facilities available to the police, military, and other communication networks will be undertaken to provide the basis for the establishment of initial requirements. This part will concern overall systems integration and alternate routing in the event of system damage.

(3) When initial requirements have been established and system specifications have been implemented, testing of such intercommunications will be conducted. The results of tests will be evaluated, and reports will be prepared to include any additional recommendations that may be indicated.

c. Types of Data Required

Statements of roles and missions, and results of observation of the practices of the police and military organizations will be required along with statements and descriptions of plans and proposed operations including those pertaining to communications.

Experiences of neighboring southeast Asian countries with similar problems of integrating communications networks and in counterinsurgency operations will be studied for application to this subtask. The type of data required will also include those items noted in Subtasks 1, 2, and 3.

d. Source of Data

A part of the required data will be obtained in conjunction with Subtask 2. It will thus be necessary to visit the Ministries, Departments, Divisions, etc., noted in Subtask 2. Also, field trips will be made to observe operations and consult with border police and military personnel at all command levels. In the event of field exercises, observations will be made of operational modes and coordination of the communication effort.

Reports and studies of experiences in southeast Asian countries will be reviewed for pertinent data.

e. Estimate of Personnel Required

It is estimated that the following personnel will be required on a full time or frequently available basis, as follows:

(1) One Thai military officer, at least of Commander, RTN, or Lt. Col. rank, with access to expected sources of data and with a Top Secret clearance. It is desired that this officer be available for 6 months full time.

(2) One US operations analyst (SRI) cleared for Top Secret.

(3) Thai officers (one from each Service, and one from the Border Patrol Police), qualified in communications and operations for his Service, to be consulted as required.

f. Estimated Length of Time of Subtask

It is estimated that it will take approximately 6 months to conduct this study. Certain parts of the study can be initiated at once in conjunction with related subtasks. This would include the gathering of the initial data pertinent to Subtasks 1, 2, 3, and 6.

g. Benefits to Thailand Expected from the Findings of This Subtask

It is expected that the benefits accruing to Thailand from this task will include:

(1) Improved operational coordination among military and police elements

(2) Improved effective interconnection of police, military, and other communications

(3) Improved utilization of existing facilities and personnel

(4) Establishment of alternate routes of communications.

h. Status

The research program has been outlined, but is inactive due to lack of approval by Thai authorities.

5. Subtask 5--Communications Systems Implications of Major Thai Dialects

a. Objective

Subtask 5 has as its objectives the determination of the hindrance to oral Thai Communications imposed by certain design characteristics of voice communications equipment employed by the military (and paramilitary) forces, and the specification of practicable improvements.

b. Approach

The meaning of words in a tonal language such as Thai, depends in part upon varying pitch. Failure to discriminate differences in pitch could, therefore, result in loss of intelligibility.

The design specifications for voice communications equipment for modern military use presumably have evolved from studies to perfect equipment for the transmission of languages other than Thai that are not tonal. The possibility exists, therefore, that presently available equipment does not embody design characteristics that are optimum for the transmission of the Thai voice. This study requires investigation of the relationship between intelligibility, pitch, and bandwidth to determine the potential magnitude of improvement in intelligibility attainable by a more optimum selection of values for these characteristics.

Essential steps of the study will include:

(1) Review of existing information on the composition of the sounds of spoken Thai.

(2) Development of a valid test of intelligibility. The Fairbanks Rhyme Test, an outgrowth of the widely used Harvard Psycho-Acoustic Laboratory Test, suggests a type of measurement tool that might be adaptable to the Thai language.

(3) Acquisition of the necessary equipment to conveniently vary and control bandwidth and signal-to-noise ratio accordingly.

(4) Measurement of the intelligibility of the voice transmissions of a panel of Thai personnel covering ranges of the three variables.

c. <u>Types of Data Required</u>

The types of data required include: (1) technical data pertaining to the design characteristics of the equipments, and/or communications channels over which the tests are conducted--e.g., bandwidth, distortion factors, noise (internal and ambient), and others that may affect circuit intelligibility; and (2) intelligibility tests (including word lists) and test scorings resulting from their use.

d. <u>Sources of Data</u>

Data concerning transmission characteristics of equipments to be tested will be obtained from manufacturers or from laboratory and field measurements in Thailand.

Native-born Thai speakers and listeners in Thailand will be used as required for speaking, listening, and recording data in connection with the Thai intelligibility tests.

e. <u>Estimates of Personnel Required</u>

Personnel estimates are:

(1) One SRI speech engineer (to plan, organize, manage, and conduct the tests, initially at Menlo Park, California, and then in Thailand).

(2) One Thai officer or civilian assistant, English speaking, to assist in planning and to coordinate the efforts of required Thai personnel.

(3) About 30 native Thai personnel, enlisted or civilian, as talkers and listeners for about 8 hours each.

f. <u>Duration of Subtask</u>

Total effort will continue for 12 months--about 6 months effort in Thailand and about 6 months in the US.

g. <u>Results Expected From This Study</u>

It is anticipated that Subtask 5 will reveal the gains in intelligibility of communication with the Thai voice that can be achieved by changes in the equipment design characteristics.

h. Status

The project requirement for evaluation of voice communication system performance in Southeast Asia seemed likely to be best satisfied by the use of "intelligibility" tests. These tests have been used for several years by communication engineers in the US, and the preparation of master test tapes in English is readily accomplished. Because the possible transmission impairment to tonal languages might vary in magnitude and type from English, a preliminary investigation of the feasibility of developing a similar type test in Thai was begun. This concept was discussed at the U.S. Army Language School, Monterey, California with Dr. Tekawa (Director, Far East Language Division). Dr. Tekawa showed considerable interest and provided several adult male Thai language instructors for the recording of selected Thai words. The demonstrated interest and cooperation suggests that the requirement for speakers in the US can be partially fulfilled with the assistance of the staff at the language school.

As a result of the first visit to the school, four texts of the Basic Thai course were obtained and have been analyzed to determine the relative frequency of occurrence of different Thai vowel forms. The counting and cataloging of these forms have been completed. Determination of relative frequencies and comparison thereof to English vowel form frequencies was begun. In addition, the recordings of selected Thai words spoken by adult male Thai language instructors have been subjected to a frequency-spectrum analysis. The technique used employs a Sonograph to produce a permanent record of the voice frequency components.

6. Subtask 6--Human Engineering, Thai Aptitudes

a. Objective

The objective of this subtask is to investigate communications personnel skills and abilities in order to determine what is required for (1) equipment design and operational procedures, and (2) personnel selection, training, and placement to provide improved communication systems performance.

b. Approach

The purpose of Subtask 6 is to increase the probability that any measurable failure in a communication system is not from human failure. Human failure includes the engineering of the equipment, the capability of the operator personnel, procedures used, etc. This investigation will also include the appraisal of manpower availability and training programs and facilities.

The research effort will attempt to determine the following:

(1) The psycho-physical traits of operator personnel that result in substandard utilization of foreign-made and Thai equipment

(2) The extent to which the human resources are sufficient to supply the necessary skills and abilities in the communication jobs

(3) The effects of equipment weight on communications performance, patrolling distance, and patrol fire power

(4) Existing language difficulties that degrade the communications within and among the military police, and other agencies

(5) The critical deficiencies and/or limitations in the capabilities of communications personnel to perform their duties under the stresses of prolonged counter-insurgency activities

(6) The minimum training requirements.

c. Types of Data Required

Data required will include:

(1) Communications skills and abilities among the military, police, and governmental agencies

(2) Anthropometric data

(3) Test performance scores of operator personnel

(4) Equipment physical characteristics and operating mechanics.

d. Sources of Data

Most of the data will be obtained from field assessments and will include:

(1) Operating units records and performance data

(2) Personnel records

(3) Training school records

(4) Operator measurements.

e. Estimate of

Required personnel of this type will include: One Thai officer and one US operations analyst.

f. Estimated Length of Time of Subtask

Eight months is the estimated duration of this subtask.

g. Results Expected From This Study

Expected results of the subtask are:

(1) Identification of skill requirements for communications jobs

(2) Establishment as to what extent loss in performance is attributable to personnel inadequacies

(3) Training school and manpower needs

(4) Identification of particular design requirements for better equipment usage

(5) Selection of tests and standards for communications operator personnel.

h. Status

The research program has been outlined but is inactive due to lack of approval by Thai authorities.

IV WORK ACCOMPLISHED DURING THE REPORTING PERIOD--TASK II

A. Introduction

Discussions between SRI, ARPA, and USAEL representatives led to the formation of a set of specific subtasks. These particular subtasks were chosen as guiding factors for work plans during the initial stages of laboratory work. Frequent review of the value of each subtask was intended, to permit new items to be substituted in place of less fruitful ones.

The initial list of subtasks served to focus the attention of personnel on a few specific tasks rather than spread the effort so thin that little would be accomplished on the broad task of investigating communication problems in tropical areas. The initial list of subtasks is given below, followed by a discussion of accomplishments under each.

Subtask 1: Testing and Evaluation of Tactical Communication Techniques and Devices

Subtask 2: Noise Measurements

Subtask 3: Antenna Orientation

Subtask 4: Ground Constants

Subtask 5: Earth Potential

Subtask 6: Frequency Prediction

Subtask 7: Antenna Terrain Effects

Subtask 8: Flutter Fading

Subtask 9: Vertical-Incidence Ionospheric Measurements

Subtask 10: Oblique-Incidence Ionospheric Measurements

Subtask 11: Technical Assistance

Subtask 12: Special Investigations

B. Subtask 1: Testing and Evaluation of Tactical Communication Techniques and Devices

1. Work Accomplished

Early in the contract, considerable emphasis was placed upon the determination of the capability and shortcomings of various radio sets for field work. Consequently, work was started on Subtask 1 even before the laboratory complex was completed. Field tests of seven types of man-pack radio sets have been conducted in forest regions of southern Thailand, over a flat delta region near Bangkok, and in a hilly forested area about 100 miles northeast of Bangkok. Both HF and VHF radio sets have been tested.

The following tests have been completed, in this order:

(1) Tests on HF and VHF sets in a forest area of southern Thailand

(2) Tests on HF sets over a flat delta region near Bangkok

(3) Tests on HF sets over a mountainous area northwest of Bangkok. This series also included tests over extended ranges up to 100 miles between terminals

(4) Tests on VHF sets over a flat delta region near Bangkok.

The field testing has been conducted under conditions as nearly operational as possible. Both voice and CW tests have been performed. Generally, results have been determined from a score based upon comparison of received text with transmitted messages. Field tests have normally been conducted on an established schedule throughout the 24-hour day.

2. Conclusions

Since there are major differences in the performance capabilities of HF and VHF sets, the test results from each class of radio sets must be treated separately. Direct comparison between HF and VHF sets has not, therefore, seemed feasible. The following comments summarize present findings:

(1) Sets employing solid-state components are noticeably lighter in weight, are smaller, and have smaller prime-power-source requirements than others. No noticeable degradation in performance was observed for the smaller and lighter radio sets. The smaller, recently designed sets generally outperformed the older sets.

(2) The frequency flexibility of the one HF set employing a versatile synthesizer providing frequencies at 1-kc intervals over its range was found to be valuable in minimizing interference effects.

(3) The antennas used had a major bearing on set performance. Of the three standard types of antennas employed, the dipole antenna performed best; the slant-wire antenna rated next; and the whip antenna gave the poorest performance.

(4) On tests using HF sets, definite diurnal variation in communication success was noted. Early morning communication was poor, owing to low ionospheric critical frequencies during the period between about 0100 and 0400 local time. (See Sec. IV-J for remarks on C-2 sounder observations.)

(5) Although it is difficult to achieve reliable tactical communications with man-pack HF radio sets in the tropical jungle, there are times during which communications can be established over rather large distances. This factor may be important in situations where the detection, monitoring, or direction finding of transmissions is undesirable.

(6) Terrain features between sites did not prove to be an important factor in communication success when HF sets were used.

(7) Observations on signal quality, fading, maximum propagating frequencies, and diurnal variations in these factors have led to the conclusion that communication during all tests using HF radios occurred via sky wave. This was true of ranges as short as 5 miles, the minimum range over which tests were conducted.

(8) There is no practical way to specify the maximum or even the best operating range for the HF sets tested. Antenna patterns affect the received signal strengths; however, the use of highly directional antennas on man-pack radios is not practical and does not seem to provide a good basis for the specification of range capability.

(9) The VHF sets tested generally provided adequate voice communication through moderate forest at ranges up to 3 miles. On one test conducted in a region of extremely dense undergrowth, total loss of signal was observed at a range of less than one-half mile.

(10) With whip antennas elevated 70 feet above ground and lashed in tree tops, adequate communication was established over a 5-mile path. When both antennas were lowered to 30 feet, communication through a moderate forest area could not be established.

(11) No significant range difference could be found between the two types of VHF sets tested in forest areas.

The above remarks summarize the results of tests conducted to date. To obtain a more complete understanding of the tests, their limitations, constraints, and results, interested readers are urged to review the reports listed in Sec. V.

3. Plans for Future Work

Plans are under way to test several VHF man-pack sets over the open, flat, delta land near Bangkok. It is believed that results obtained here will be applicable to other areas in southeast Asia used mainly for rice production.

Discussions are under way concerning additional testing of VHF sets in forest and jungle areas. In addition, discussions have been held concerning the desirability of field testing several special-purpose radio sets in Thailand.

C. Subtask 2: Noise Measurements

1. General

Early in the program, it was recognized that radio noise levels limit the performance of field radio sets. The frequency of tropical thunderstorms emphasizes the need for an understanding of the magnitude and variations of noise levels. While considerable knowledge is available on tropical noise levels from the existing world-wide noise-measuring network and from a wide variety of scientific explorations, several specific problems related to the interpretation of performance of field radio sets remain. Some of these follow:

(1) Noise level measurements are required simultaneously with the field testing of radio sets if accurate results are to be obtained and if these results are to be extrapolated to locations with different noise levels.

(2) Field radio sets frequently employ horizontally polarized antennas. The existing world-wide noise measurements were made by using vertical antennas over ground screens. No known experiment has related noise maps obtained from the existing network to the use of horizontally polarized antennas.

(3) It is believed that most noise energy arrives at relatively low angles of incidence. No known data exist indicating that tropical vegetation could absorb more energy, thus reducing effective noise levels for radio sets used in tropical forests.

2. Work Undertaken

Under Subtask 2, an investigation has been started on the design of an experiment to investigate a variety of problems including those listed above. Equipment parameters and the general specifications for noise equipment have been explored. The possibility of obtaining a standard ARN-2 noise measurement equipment identical to those used in the world-wide network has been explored.

To initiate a measurement program, an available five-channel VLF and LF noise recorder was shipped to Thailand and placed in operation. Various specific single-frequency noise explorations have been made by using an Empire Devices NF205 noise measurement set; however, a comprehensive program has not been feasible because of its limited dynamic range and single frequency.

3. Plans for Future Work

A detailed test plan for subtask work is being prepared and will be completed in the next reporting period. In addition, the design of a suitable noise receiver is under way. Personnel from the Boulder Laboratories of the National Bureau of Standards (NBS) have indicated a willingness to cooperate and assist in the design. Emphasis has been given to a design providing data consistent with those obtained by the network of ARN-2 noise receivers now operating around the world.

D. Subtask 3: Antenna Orientation

1. Work Undertaken

It is normal procedure to orient dipole antennas broadside to each other for HF communication.[1*] Theoretical and experimental evidence

* References are given at the end of the report.

indicates that such an orientation is not always the best, especially for short paths near the equator where the earth's magnetic field is essentially orthogonal to the near-vertical propagation path. The polarization of down-coming ionospherically propagated signals and the differential absorption between ordinary and extraordinary waves are factors affecting optimum orientation of a dipole or any linearly polarized antenna.

A theoretical investigation of the factors related to antenna orientation near the magnetic equator was undertaken.[2] Early tests indicated that an improved communication capability should result if all antennas were oriented in a north-south direction. A field experiment was designed to measure received field strength for antennas with various orientations.

Initial measurements using CW signals as signal sources have been completed on the paths between Bangkok and Ayudhaya and between Bangkok and Nakornpathom, which are approximately 60 km due north and due west of Bangkok. Transmissions on frequencies of 1.7, 3, 5, and 10 Mc were employed in the CW test.

2. Early Results

Early results indicate a significant enhancement in signal strength using north-south antennas compared to east-west antennas for the lower frequencies and little difference at the two higher frequencies. The data have not been fully examined, so firm conclusions can not be made at this time.[3]

3. Plans for Future Work

Data reduction and analysis of CW and pulse experiments will continue. It is anticipated that two special technical reports will be required to describe field results.

A revised and expanded edition of Research Memorandum 5, entitled "Orientation of Linearly Polarized HF Antennas for Short-Path Communication via the Ionosphere near the Geomagnetic Equator," is being prepared for publication. Also work will continue on a report investigating theoretical aspects of absorption of near-vertical radio waves in equatorial regions.

It is anticipated that all field work under the subtask will be completed during the next six-month period.

E. Subtask 4: Ground Constants

1. Work Undertaken

A program measuring both conductivity and dielectric constant of typical soil. found throughout Thailand was undertaken. The values are useful in calculating signal strengths and the effective range of ground waves emitted from radio transmitters. The program is under way and measurements have been made in more than a dozen locations. Dielectric constant is measured by the ~~wave~~-tilt method and ground conductivity is determined by the comparison, with precomputed values, of the measured field-strength profiles along radials from the transmitter. A map of Thailand has been prepared showing initial results; however, to be meaningful its publication must await the result of additional measurements.

2. Plans for Future Work

Field crews will continue to measure ground constants throughout Thailand. Occasional repeat measurements are planned so that variations in results between dry and wet seasons can be obtained. Techniques for the presentation of data will be examined with the emphasis on use of simple map presentations.

F. Subtask 5: Earth Potential

1. Work Undertaken

During the testing of man-pack radios it became apparent that an indicator of ionospheric stability was highly desirable and perhaps even necessary to interpret the results. Since no means of measuring ionospheric or magnetic state existed in Thailand, an attempt was made to construct a device to observe and record earth potential. Because of the emphasis placed upon obtaining results of radio-set testing, inadequate attention was given the design and installation of the earth-potential gear. A properly operating installation was not obtained.

2. Termination of Effort

Since magnetometers have been so highly developed, it appeared that they should be used instead of the crude and difficult-to-interpret earth-potential measurements. Consequently, a recommendation was made to drop the subtask and the small effort under way was stopped very early in the program.

G. Subtask 6: Frequency Prediction

1. General

Since in virtually all practical situations where HF field radios are used for short-range communication in tropical areas, a path via the ionosphere is utilized, prediction techniques can be used to determine optimum frequency assignments. The United States Army publishes a set of predictions computed for ionospheric conditions over southeast Asia.[3]

Radio propagation predictions are derived from world-wide maps of critical frequencies and ionospheric height.[4] The predictions give calculated average values of maximum useful frequency (MUF) and lowest useful frequency (LUF).[5,6] Actual values can deviate considerably from predicted values. An investigation of the difference between predictions and the actual values of MUF-LUF was deemed desirable. Also, since ionospheric maps covering Thailand have been based upon data from distant vertical-incidence sounders, the presence of a nearby vertical sounder was recommended (see Sec. IV-I.)

2. Work Undertaken

A detailed review of the factors used in the computation of predictions was undertaken with the objective of improving predictions in local southeast Asia, with particular emphasis on Thailand.

Under Subtask 6, several specific frequency-prediction computations were made by USASRPA and SRI for military exercises in Thailand. For example, Exercise Kitti 07 was a large-scale maneuver covering all of Thailand and designed to improve the ability of the Thai Military Forces to combat counterinsurgency problems. A wide variety of

communication problems were dealt with during the exercise, including the operation of HF circuits using AM voice, CW, and radio teletype. Transmitter powers ranged from 15 to 400 watts, and many different antennas were employed. Propagation predictions were supplied by USASRPA and SRI for circuits terminating at the locations shown in Fig. 7. Field assistance was supplied during the exercise to instruct in the use of propagation predictions and assist in their interpretation.

After the network was installed, it was immediately put into operational use, which made difficult the collection of accurate performance data. The SRI personnel available were not sufficient to cover and monitor all major stations throughout the exercise. Normal field communication logs did not provide sufficient detail to permit evaluation of propagation predictions. Consequently, no firm measure of the value of the predictions to field operators could be obtained.

3. Plans for Future Work

Theoretical studies and the examination of ionospheric data will continue. Many months of ionospheric data must be accumulated before the accuracy of prediction techniques can be adequately evaluated. C-2 data reports planned under Subtask 9 will provide the major data base, although data obtained from all subtasks will be used.

It is anticipated that occasional special predictions for communication circuits within Thailand will be produced.

H. Subtask 7: Antenna Terrain Effects

1. General

It was recognized that terrain and tropical vegetation would affect the radiation pattern of antennas employed in both VHF and HF field radio sets. The effect on patterns is complex. Understanding of it requires that the radiation pattern of a field antenna be known, the details of the earth's surface in the immediate vicinity of the antenna be understood, and the effect on the radiation pattern when the antenna is immersed in a tropical forest be determined.

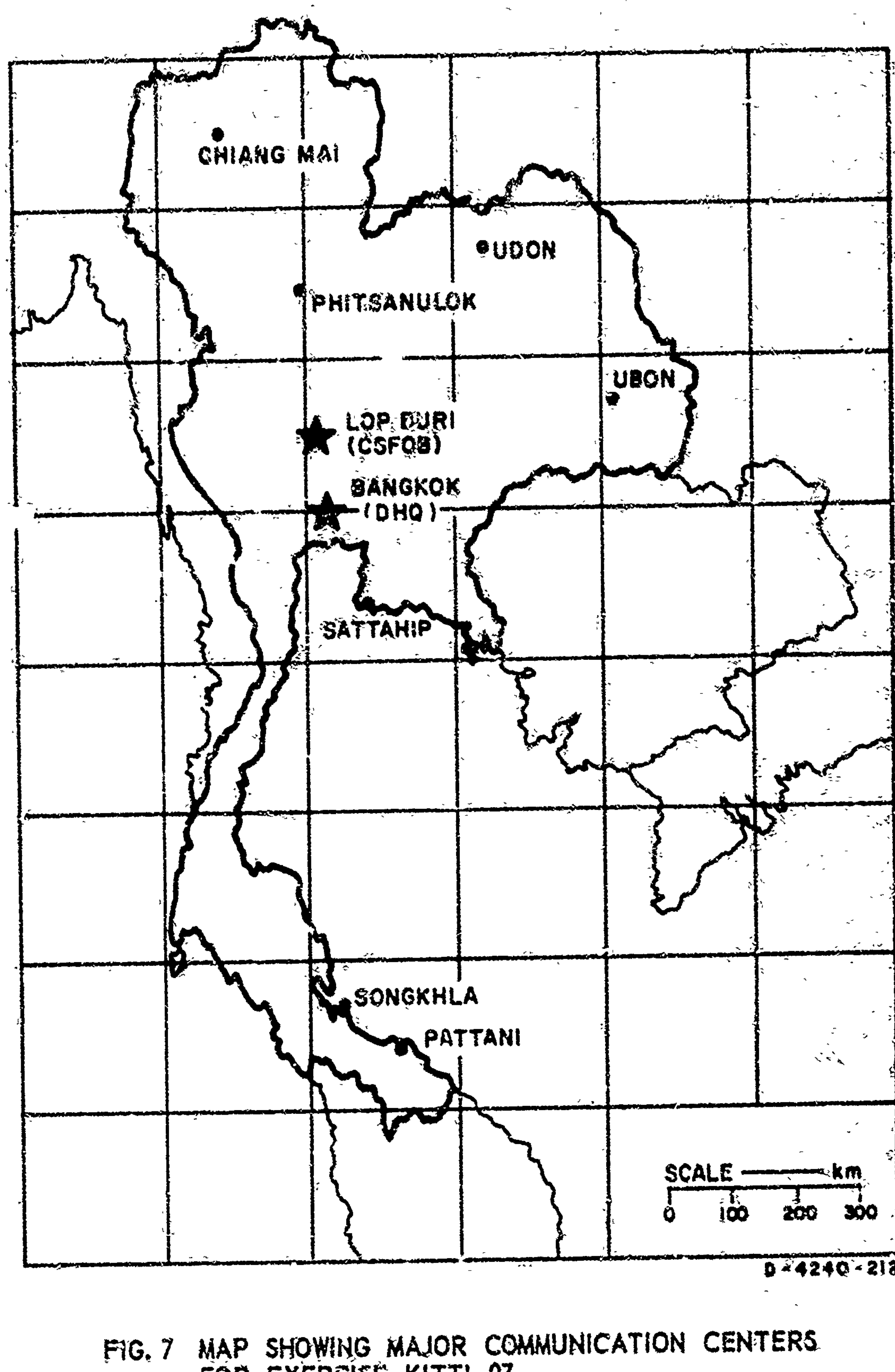

FIG. 7 MAP SHOWING MAJOR COMMUNICATION CENTERS FOR EXERCISE KITTI 07

2. Work Undertaken

While a considerable body of data exists enabling one to estimate the patterns of dipole and whip antennas, no reference could be found concerning the patterns of the widely used slant-wire antennas with counterpoise. Consequently, a brief measurement program was undertaken to measure patterns of scale-model slant-wire antennas.

3. Early Conclusions

The measurements indicated that slant-wire antennas will generally have a null at high and low take-off angles. The null in the pattern at near-vertical radiation angles raises serious doubt concerning the usability of the slant-wire antenna for field communication in tropical forest areas.

Further investigation into the characteristics of selected slant-wire antenna designs that are in field use has indicated that the ratio between the length of the counterpoise and the length of the radiator is critical and if improperly chosen can result in loss of efficiency due to high dissipation in the counterpoise.

4. Future Work

Several discussions were held between ARPA, USAEL, and SRI representatives concerning the direct full-scale measurement of the effective antenna patterns immersed in a forest area. Stanford Research Institute's "Xeledop" full-scale pattern measurement technique is ideal for such a measurement. It could provide direct answers to such questions as:

(1) Is attenuation from tropical forest affected by polarization?

(2) Is there sufficient attenuation of low-angle radiation of antennas immersed in tropical vegetation to be a factor in reducing the possibility of HF transmissions being monitored?

(3) Is there sufficient attenuation of low-angle signals to reduce the possibility of direction finding by distant enemy installations?

(4) Is there sufficient attenuation of low-angle signals to significantly reduce the interference levels in HF field radios caused by long-distance high-power stations?

(5) Is there sufficient attenuation of low angle radio noise energy to significantly reduce receiver noise levels of HF stations with antennas immersed in a forest?

These questions imply that advantages might result from the deliberate placement of short-range HF field radio stations in dense forest areas rather than in open fields, when such a choice is available. Studies and measurements to investigate such possibilities are desirable, and detailed plans are being formulated for review by USAEL and ARPA representatives.

I. Subtask 8: Flutter Fading

1. General

The experience of NBS workers in Africa, of Voice of America investigations, and of other scientific explorations has shown that perturbations of both frequency and amplitude components of a transmitted signal (commonly called flutter fading) occur near the magnetic equator. Flutter fading is similar to the auroral sputter commonly observed in polar regions. It can affect the intelligibility of both voice and CW signals from field radios.

Since flutter fading has not been extensively studied in southeast Asia, little has been known regarding its frequency of occurrence and its geographic variations.

2. Work Undertaken

During the period covered by this report, a comprehensive review has been made of all experiments and measurements on flutter fading (see comments on the literature survey in Sec. V), and conferences have been held with many of the participants in past work. Techniques for the systematic measurements of flutter fading have been explored.

3. Recommendation

A recommendation has been made to ARPA and USAEL that a flutter-fading receiving system similar to that used by the Boulder Laboratory of NBS be provided for Thailand.

J. Subtask 9: Vertical-Incidence Ionospheric Measurements

As discussed in Sec. II, a cooperative effort by USAEL and USASRPA resulted in the availability of a C-2 vertical-incidence sounder housed in a van.

1. Work Accomplished

Assistance was supplied by SRI to USASRPA in providing land, filling the land, pouring a concrete pad for the sounder van, erecting the antenna tower, providing spare parts, etc. Data scaled by USASRPA technicians have been placed in convenient tabular forms consistent with URSI standards by SRI personnel.

2. Plans for Future Work

Monthly data reports are planned so that long-term data can be conveniently available. Arrangements have been made to exchange data with other organizations in southeast Asia so that geographic variations of ionospheric phenomena can be studied.

K. Subtask 10: Oblique-Incidence Ionospheric Measurements

1. Background

During the early field test stages of Subtask 1, it became apparent that an oblique-incidence sounder would be a valuable tool if installed directly in parallel with the test path. The oblique sounder would provide:

(1) Positive resolution, identification, and measurement of each propagation path, through short-pulse time measurements

(2) An on-the-spot real-time measurement of ionospheric stability so that tests could be stopped during storms or, if they were not stopped, so that data could be properly evaluated

(3) Positive measurement of spread-F conditions, which result in both time and frequency distortion of signals propagated via the ionosphere. (A reduction of message intelligibility can result from such conditions regardless of the type of set under test.)

(4) Comparisons of performance of various antennas by automatically switching from one to another and recording the amplitude of received signal of each frequency channel of the sounder

(5) An educational device to demonstrate details of the nature of the propagation path between two locations a short distance apart.

2. Work Undertaken

To gain some experience in the operation of an oblique-incidence sounder over a very short distance, an existing transmitter was operated at Menlo Park, California, and a sounder receiver was operated at the Mountain View, California field site. The separation was about 5 miles. Both dipole and whip antennas were employed. The terrain between the sites is very flat and contains the built-up areas of Palo Alto and Mountain View.

3. Results

While no conclusions concerning tropical communications were obtained during the brief test, it was apparent that sky-wave transmission was the strongest mode most of the time. Multiple-hop sky-wave was also observed. The ground wave was weak but readable and clearly separable from the sky-wave signals.

4. Plans for Future Work

Discussions are under way between SRI and USAEL concerning the availability of oblique-incidence sounders for use in the forest areas of Thailand. No further action can be taken until the availability of sounders is determined.

L. Subtask 11: Technical Assistance

1. Objectives

Since the MRDC Electronics Laboratory has placed in Thailand a modern, well equipped electronics research and measurement facility, it was anticipated that a variety of small tasks would arise requiring consulting, study, or possibly equipment modification efforts.

2. Activities

Examples of activities that have arisen are:

(1) Conduct of a test equipment calibration, maintenance, and repair class for Thai military technicians

(2) Conferences with Chulalongkorn University staff members to discuss their research problems and plans

(3) Occasional loan of scientific equipment to Chulalongkorn University projects.

M. Subtask 12: Special Investigations

No special investigations of consequence were undertaken. Since the objectives of Subtask 12 and Subtask 11 are substantially similar, it is recommended that Subtask 12 be dropped.

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V SUMMARY OF REPORTS PUBLISHED

All required monthly progress reports for the period covered by this report have been submitted. These reports covered the efforts of both Task I and Task II.

In addition to the monthly reports, Task I and Task II have jointly submitted Semi-Annual Report 1 and Semi-Annual Report 2, summarizing work accomplished during the first and second six-month period respectively.

Task II has completed the Research Memorandums* listed below, with abstracts, covering work on specific technical areas under investigation:

Research Memorandum 2, "Voice Tests on Man-Pack Radios in a Tropical Environment," by W. R. Vincent (July 1963).

ABSTRACT

Under the direction of the Advanced Research Projects Agency and the United States Army Electronic Research and Development Laboratory, Stanford Research Institute conducted a field test program to compare the performance of selected man-pack radio sets under various tropical terrain and weather conditions. Initial steps had already been taken to establish a Tropical Communication Laboratory as part of the Combat Development and Test Center (CDTC) in Thailand. The formation of the basic laboratory and the assignment of personnel were hastened to accomplish the desired field tests.

This report describes the results of voice tests on the selected man-pack radio sets in a tropical forest environment. It will be followed by reports on the performance of the sets in other terrain environments.

Research Memorandum 3, "Field Tests on Man-Pack Radios in a Tropical Environment," by W. R. Vincent (July 1963).

*These reports should have been issued as Special Technical Reports; future reports in this series will be called Special Technical Reports.

ABSTRACT

Under the direction of the Advanced Research Projects Agency and the United States Army Electronic Research and Development Laboratory, Stanford Research Institute conducted a field test program to compare the performance of selected man-pack radio sets under various tropical terrain, vegetation, and weather conditions. Research Memorandum 2 under this contract describes results obtained in a tropical forest area. This memorandum contains data on all tests completed to its date of issue, including those data presented in Research Memorandum 2, so that all test data can be available in one report and comparisons can be made.

Initial steps had been taken to establish a Communication Laboratory as a portion of the Combat Development and Test Center (CDTC) in Thailand. The formation of the basic laboratory was hastened and personnel assignments altered to provide adequate field test crews. Laboratory equipment did not become available to support the field effort until the later stages of the test progr-- However, the availability of a central headquarters, .emporary laboratory, and the meager repair facilities and support did facilitate the field tests somewhat.

This report describes the results of voice and CW tests on selected man-pack sets. Tests were conducted in the tropical forest area in southern Thailand, the rice paddy area of the low delta region near Bangkok, and the mountains about 100 miles north of Bangkok.

Research Memorandum 4, "Scale-Model Measurements on a Sloping-Wire Antenna," by T. S. Cory (June 1963).

ABSTRACT

Radiation patterns of a 1:100-scale model of an end-fed sloping-wire antenna have been measured. The model antenna was made to simulate a tactical HF (3-to-8-Mc) communication antenna used with the AN/TRC-77 radio set. Such an antenna is of particular interest for tactical jungle communications where near-vertical propagation is pertinent rather than ground-wave.

The actual antenna, in addition to the sloping radiator, comes with two 50-foot counterpoise radials separated by 90 degrees on the ground. Since the model was measured in the presence of metal ground surfaces, the effect of the counterpoise on the radiation patterns is not shown. Because the radiator itself is electrically short (0.076-0.203 λ), the counterpoise is expected to improve the radiation efficiency and to have a minimal effect on the radiation patterns.

On a scale-model basis, it is difficult to be more precise about the patterns than is indicated in this report, because of the difficulty in scaling ground constants. It is possible to measure the free-space patterns of a symmetric sloping-wire structure in free space and reflect this mathematically into a ground geometry that may be controlled. This latter approach is currently being investigated, along with an experimental program to determine the location of effective ground with respect to the earth's surface. As near-vertical radiation is of primary interest, the geometrical optics approach of ground reflection is expected to yield useful answers. Near grazing for vertical polarization, the geometrical optics technique breaks down, and the reflection must be considered as a diffraction problem.

The sloping-wire-antenna patterns were measured in the presence of a plane metallic reflecting ground, and in the presence of a 25-degree conical hill. Elevation-plane patterns were obtained for two orthogonal polarizations.

Research Memorandum 5, "Orientation of Linearly Polarized HF Antennas for Short-Path Communication via the Ionosphere near the Geomagnetic Equator," by G. H. Hagn (August 1963).

ABSTRACT

This report suggests that there is an optimum orientation for linearly polarized antennas used on short ionospheric paths near the geomagnetic equator. Consideration of the magneto-ionic theory and its application to antenna-to-medium coupling problems indicate that aligning such antennas parallel to the earth's magnetic field will maximize signal strength while minimizing polarization fading. Such orientations may intercept less interference than vertically polarized antennas. If this is true, the signal-to-noise ratio would be maximized and the orientation would be truly optimum. Experiments to test these hypotheses are outlined.

In addition to these published reports, several reports are currently in various stages of preparation. Examples of these are (1) a revision and updating of Research Memorandum 5, (2) a survey of the literature on equatorial communication, (3) a report entitled "Absorption of Ionospherically Propagated HF Radio Waves under Conditions Where the QT Approximation is Valid," and (4) monthly vertical-incidence sounder data reports.

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